EFFECT OF STORAGE ON SENSORY PROPERTIES OF FRESH-CUT CANTALOUPE VARIETIES

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Accepted for Publication June 25, 2002

ABSTRACT

The sensory properties of fresh-cut fruit deteriorate before visual sensory properties. An appealing look that has lost its appealing flavor will not result in repeat purchases. The sensory attributes were characterized for 4 varieties of cantaloupes and monitored for change during storage using descriptive sensory analysis. The 4 varieties, Athena, Sol Real, Primo and Pacstart, were produced in 1999 and 2000. The melons were prepared and stored in rigid packaging. Variety significantly affected sweet aromatic, chemical, sweet, astringent, hardness, moisture release and surface wetness. Pacstart was lower in 'Fruity' and 'Sweet' intensity. At the ideal condition 4C, little change occurred during storage. Cucurbits, cohesiveness and surface wetness significantly changes during 7 days of storage. Sol Real and Pacstart were significantly harder than Athena and Primo. Sol Real decreased in hardness. Off-flavor development was minimal.

INTRODUCTION

Maintaining flavor and texture attributes of fresh-cut produce is critical to the continued expansion of the fresh-cut melon industry (Bett 2002; Beaulieu 2001). Muskmelons are highly regarded for their unique flavor and high sugar levels which are determinants of quality (Bianco and Pratt 1977; Yamaguchi *et al.* 1977). In cantaloupe, development of an abscission layer at the vine is the usual indicator of optimum ripeness and harvest time. Fruit harvested before development of the abscission zone will not develop flavor and volatiles similar to fruit that remains on the vine until fully ripe (Beaulieu and Grimm 2001; Pratt

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Journal of Food Quality 26 (2003) 323-335.

1971; Wyllie *et al.* 1995). In fresh-cut fruit, flavors tend to deteriorate at a quicker rate than appearance does (Ayhan *et al.* 1998). Since consumers purchase the product based on appearance because the protective packaging prevents them from determining aroma characteristics, this loss of flavor has the potential of reducing the number of repeat purchases (Beaulieu and Baldwin 2002). The descriptive flavor and texture (Bett 2002) characteristics of melons have not previously been detailed in the literature. Much of the sensory work published thus far for fresh-cut melon has been general terms such as odor, taste, overall flavor, overall texture, and have utilized hedonic scales and a small number of panelists (<5) (Ayhan *et al.* 1998; O'Connor-Shaw *et al.* 1994). Portela and Cantewell (1998) assessed sweet taste and off-flavor, also. O'Connor-Shaw *et al.* (1996) used 6 panelists and added the texture attributes 'juiciness' and 'softness'. Only two studies were found where numerous panelists were utilized; Mutton *et al.* (1981) used 25 panelists (minimum) per session in their hedonic appraisal of rockmelons and Yamaguchi *et al.* (1977) used 18 judges to discriminate flavor in melons via hedonic appraisals. These researchers value the importance of sensory evaluation in monitoring quality of fresh-cut fruit, but did not utilize detailed flavor and texture descriptors with definitions for studying the sensory changes that occur during storage. Soluble solids (SS) in five cantaloupe varieties was only partially correlated with sweetness (Mutton *et al.* 1981; Yamaguchi *et al.* 1977), and high SS alone does not appear to adequately define good melon quality (Aulenbach and Worthington 1974; Currence and Larson 1941; Mutton *et al.* 1981). Furthermore, hedonic panel scores for aroma were poorly correlated with total volatiles and eating quality (Yamaguchi *et al.* 1977). The purpose of this research was to utilize descriptive flavor and texture analysis to characterize sensory quality changes in four varieties of cantaloupe during fresh-cut storage at optimum storage temperature, and contrast the role varietal differences play in these changes.

MATERIALS AND METHODS

Plant Material

Cantaloupes (*Cucumis melo* var. *reticulatus*) (Sol Real, Primo and Pacstart) were grown in Kettleman City, CA, on raised beds with standard cultural practices in a commercial field with furrow irrigation. Ripe Athena fruit were harvested in Valdosta, GA. Developing fruit were harvested 38 days after pollination (DAP) at 3/4 slip, hydrocooled in an ice slurry in the field, packed carefully with styrofoam packaging beads and shipped overnight to the SRRC laboratory in New Orleans, for processing. All four varieties were sampled in 1999 and 2000.

Fresh-cut and Sample Preparation

Whole fruit were inspected carefully for bruises, compression damage and the presence of fungus on the rind and culled if not in optimum condition 5 to 7 days after harvest (DAH). Fruit were washed thoroughly in cold running tap water then sanitized in 100 ppm bleach, rinsed and uniformly peeled on a CP-44 Melon Peeler (Muro Corp., Tokyo). The stem and blossom portions (~2 to 3 cm) were cut off and each melon was sliced once longitudinally then seeds removed and the seed cavity cleaned, halves were placed face-down on a cutting board and roughly 2.5 cm equatorial slices were cut, from which, all loose endocarp seed cavity tissues (1 to 2 mm thick) was removed. Approximately 2 to 3 cm $\times$ 2.5 cm cubes were prepared in pie-like wedges cut from the 2.5 cm wide slices. Good manufacturing practices and strict sanitary conditions were strictly adhered to during processing and all subsequent handling stages. Four to 6 melons from each variety were processed for the experiment per year. Approximately 300 g of cubes were randomly placed into 24 ounce (~ 1 L) low profile Juice Catcher containers (SRW-24-JC, Winkler Forming, Carrollton, TX). Juice Catcher containers were stored at 4C and fresh-cut cubes were assessed after storage. The 1999 crop was sampled at 0, 3, 5, 7 and 10 days postprocessing (DPP). In 2000, Sol Real and Athena were sampled at 0, 3, 5, 7, 10, 12 and 14 DPP, and Primo and Pacstart were sampled at 0, 2, 7, 9 and 14 DPP. Due to the exceptionally good quality of fruit at 10 days storage in 1999, the researchers decided to carry out the experiment to 14 days in the 2000 season. Due to some constraints of harvest, one half of the varieties were presented at different sessions than the other varieties. Because of scheduling conflicts the sampling days were different in all but the 0 and 7 day sessions. Soluble solids (brix °) were measured from expressed cubes (5 cubes per replicate (3 replicates)) with a hand held electronic refractometer (Atago, PR101, Tokyo).

Descriptive Sensory Analysis

Twelve trained panelists, having from one to eight years experience in descriptive sensory (Meilgaard *et al.* 1999) work participated in the experiment. They evaluated nine flavor and five texture attributes (Tables 1 and 2). Five cubes equilibrated to 24C were placed in glass custard cups and covered with inverted watch glasses that extended at least 13 mm over the edge of the cups. The cups were labeled with 3-digit random numbers. Panelists slid the watch glass back to allow the headspace to enter the nose. They evaluated the intensities of the various aromas emitted from the samples. Then they placed one cube in their mouth and chewed to prepare for swallowing, but expectorated the sample. All descriptors were evaluated for intensity. If the flavor descriptor was observed with a different intensity in aroma and flavor by mouth or in two different cubes, then an estimated average was recorded by the panelists. Flavor and texture attribute intensity was rated on a 0 to 15-point anchored scale with 0 being not detectable and 15 being more intense than most foods (Meilgaard *et al.* 1999). A warm-up sample (a sufficient quantity of a locally purchased unidentified variety melon) was presented first to reduce the first sample position bias. Thereafter, the experimental samples were presented monadically in random order within a session. All panelists received the samples in the same order. All samples for a given storage day (i.e., day 0) were presented at one session in 1999 and Athena and Sol Real were presented at one session and Primo and Pacstart were presented at another session for 2000 crop year. Panelists rinsed with filtered water between samples and used unsalted saltine crackers to cleanse their palates.

TABLE 1.
MELON FLAVOR DESCRIPTORS AND DEFINITIONS

AROMATICS	
1. **Fruity/Melon**	A mixture of aromatics associated with melons (cantaloupes, honeydews, watermelon, etc.) and other fresh fruit.
2. **Cucurbits**	Aromatics associated with cucurbits such as pumpkins, cucumbers, and squash.
3. **Sweet Aromatic**	The aromatic associated with materials that also have a sweet taste such as honey, caramelized sugar, and cotton candy.
4. **Waterlike**	Aromatics of the minerals and metals commonly associated with tap water. This excludes any chlorine aromatics which may be perceived.
5. **Musty**	Aromatic associated with mold or dirt such as geosmin and 2-methyl isoborneol.
6. **Chemical**	Aromatics commonly associated with solvents, cleaning compounds, and hydrocarbons.
7. **Rancid/Painty**	Aromatic associated with oxidized fats and oils.
TASTES	
8. **Sweet**	The taste on the tongue associated with sugars.
MOUTHFEELS	
9. **Astringent**	The chemical feeling factor on the tongue described as puckering/dry, and associated with strong tea.

TABLE 2.
MELON SENSORY TEXTURE ATTRIBUTES

Phase 1: Surface Properties	
Wetness	The amount of moisture, due to an aqueous system, on the surface 3.0; internal surface of raw carrots=>15.0; water
Phase 2: First Compression Properties	
Hardness	The force to compress between molars. 1.0; cream cheese=>11.0; shelled almonds
Moisture Release	Amount of wetness/juiciness released from the sample. 2.0; Betty Crocker Gushers=>12.0; grapes
Cohesiveness	The degree to which sample deforms rather than crumbles, cracks, or breaks. 1.0; corn muffin=>12.5; Starburst candy chews
Denseness	The compactness of the cross section. 2.5; marshmallow=>13.0; Farley fruit slices

Statistics

Because of the inconsistencies in sampling days from 1999 to 2000, the only data included in the statistical analysis were all treatment combinations (variety by year) sampled at days 0 and 7. Each of the 14 attributes was analyzed as a randomized complete block design, with panelists as blocks; with a three-way treatment structure, year, day and variety. If an individual panelist had a calculated variance below the lower confidence interval (99.5%) for each attribute by year by day combination, then he or she was deemed a nondiscerner and his/her scores were discarded from the analysis for that attribute (Bett *et al.* 1993). A total of 12 panelist/attribute sets were discarded (sweet aromatic - 1, chemical - 2, cohesiveness - 2, cucurbit - 1, moisture release - 1, musty - 2, rancid - 1, sweet - 1, surface wetness - 1). All panelists were included in the analysis of astringent, density, fruity, hardness and water-like. Seven attributes had a right skewed distribution and were transformed prior to inferential analysis with a displaced log transformation $\log(Y+\alpha)$, where Y = attribute value and α = displacement (Berry 1987) (cucurbit, density, fruity/melon, moisture release, sweet and water-like). The guide for choosing α is the profile log likelihood for alpha. Wetness was normalized by squaring the response.

TABLE 3.
SUMMARY OF THE *P*-VALUES FOR ATTRIBUTE ANALYSIS FOR A RANDOMIZED COMPLETE BLOCK DESIGN (PANELIST) WITH A THREE-WAY TREATMENT STRUCTURE (VARIETY, YEAR, DAY)

Attribute	Variety	Year	Day	Variety x Year	Variety x Day	Year x Day	Variety x Year x Day
ARO	**0.023***	0.230	0.548	0.346	0.202	0.772	0.903
AST	**0.016**	**0.000**	0.371	0.436	0.565	**0.007**	0.551
CHE	**0.016**	**0.000**	0.424	**0.013**	0.230	0.324	0.356
COH	0.091	0.124	**0.014**	0.160	0.319	0.068	0.777
log (CUC+3.5)#	0.475	0.384	**0.019**	0.339	0.272	0.691	0.069
log (DEN+3.5)#	0.722	**0.000**	0.283	0.786	0.595	**0.019**	0.830
log (FRU+7.0)#	0.177	**0.000**	0.213	0.644	0.455	0.173	0.796
HAR	**0.000**	0.781	0.317	0.100	0.123	0.628	0.058
log (MOI+0.05)#	**0.003**	**0.000**	0.512	**0.004**	0.186	**0.023**	0.115
MUS	0.301	**0.028**	0.320	0.147	0.292	0.751	0.591
RAN	0.534	0.256	0.448	0.404	0.596	0.538	0.256
log (SWE +5.0)#	**0.000**	**0.000**	0.075	0.100	0.266	**0.024**	0.491
log (WAT+6.0)#	0.608	**0.000**	**0.038**	0.746	0.603	0.525	0.324
$(WET)^2$$	**0.019**	**0.000**	0.609	0.100	0.427	**0.035**	0.668

ARO=Sweet Aromatic, AST=Astringent, CHE=chemical, COH=Cohesiveness, CUC=Cucurbits, DEN=Density, FRU=Fruity/Melon, HAR=Hardness, MOI=Moisture Release, MUS=Musty, RAN=Rancid/Painty, SWE=Sweet, WAT=Waterlike, and WET=Wetness.

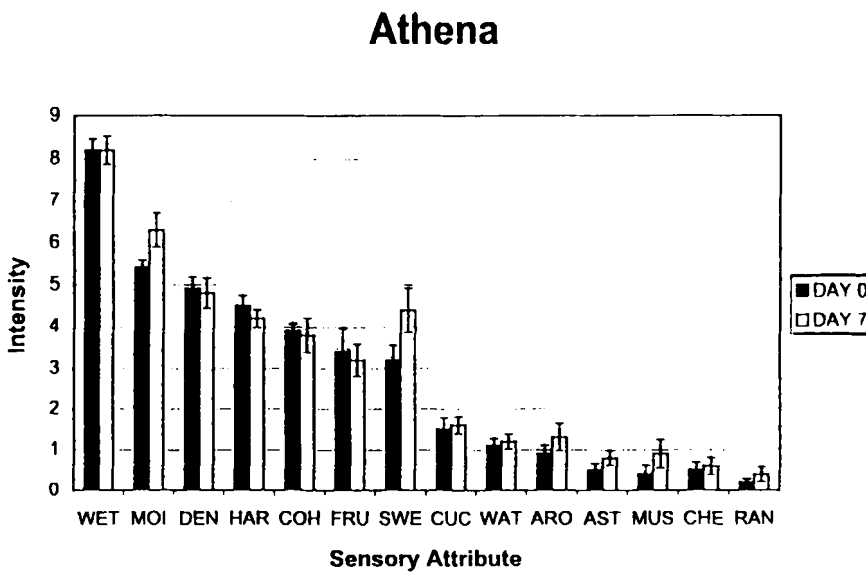
* P-values in bold type indicate significant differences between treatment levels.
#Transformation to alleviate right skewness
$ Transformation to achieve a normal distribution

RESULTS AND DISCUSSION

Variety of melon did not have a statistically significant ($\alpha=0.05$) effect on the storage life (variety by storage interaction) for any attributes under the conditions of this experiment. Variety (by itself) had a significant effect on sweet aromatic, chemical, sweetness, astringent, hardness and moisture release. Fruit flavor and sweet taste are some of the most important flavor attributes, while hardness, moisture release and surface wetness are very important to texture. Year had a significant effect on fruity flavor with 2000 fruit being more intense (3.9) than 1999 fruit (2.9). Since year effect and panel drift are statistically confounded, it is uncertain if the difference due to year effect is due to weather conditions or change in panelists' responses. Using intensity standards should help with panelists' drift, but it was observed that most scores were generally lower in 1999. There were no statistically significant differences in fruity flavor among varieties. Fruity decreased (but not significantly) during 7 DPP for all varieties except Pacstart, but Pacstart had a lower initial intensity of fruity flavor than the other varieties (Fig. 1a-1d). More intense fruity flavor at cutting results in more fruity flavor during the first few days of shelf-life. The experiment was carried to 14 DPP for the 2000 crop year and to 10 DPP for 1999. Although it did not matter how intense fruity was initially, after 10 DPP in 1999 (14 DPP for 2000 data) the intensity was below 2.7 units for each variety (data not shown).

Sol Real was significantly more intense in sweet aromatic flavor (1.7) than the other varieties. Primo was a little less intense (1.5). Pacstart (1.2) and Athena (1.1) were the lowest. There were no significant trends during storage. The researchers believe this flavor contributes positively to the flavor impact.

Variety had a significant effect on sweet taste. Athena (3.8), Primo (3.9) and Sol Real (3.8) were much more sweet than Pacstart (2.6). SS had the same trend (Table 4). Although not significant at $\alpha < 0.05$ sweet taste increased from 0 to 7 DPP in Pacstart and Sol Real. Primo had little change during storage. Based on standard errors, Athena increased significantly between 0 and 7 days. Observing all storage points, sweet taste increased after processing, but decreased to a minimum at around 10 to 14 DPP (data not shown). In 1999, all western fruit and fields looked normal upon harvest. However, the Pacstart field was apparently infected with an insect-vectored virus, because the vines uncharacteristically died back about 7 days after the harvest. Similar to previous reports (Shalitin and Wolf 2000), relatively low soluble solids and sweetness in Pacstart may have been attributed to a likely viral infection that was already in progress at harvest. Sweet taste in Pacstart was more intense in the 2000 crop, but still was less intense than the other varieties. SS had only a very slight increase around 7 to 10 DPP. In year 2000, the 14 DPP samples were consistently lower in SS than 7 or 10 DPP. This indicates that solids decrease


Athena
9
8
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6
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Intensity
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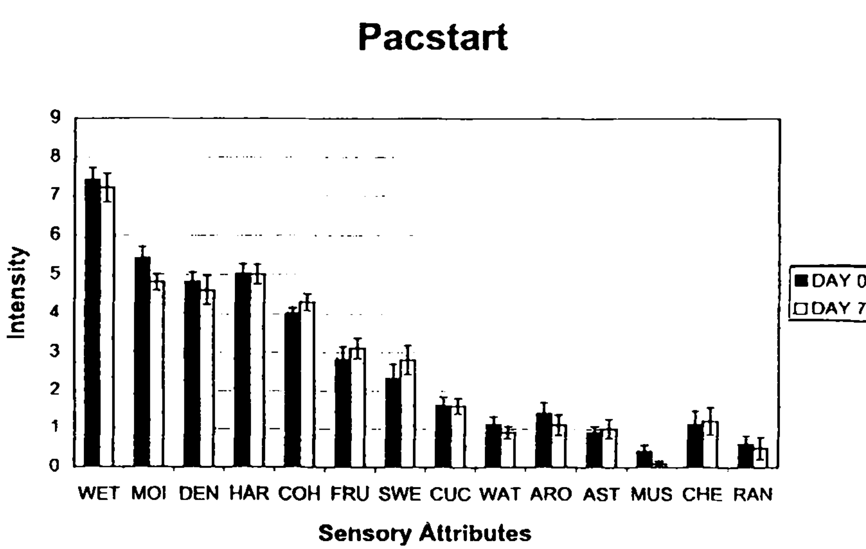
Sensory Attribute
DAY 0
DAY 7


Pacstart
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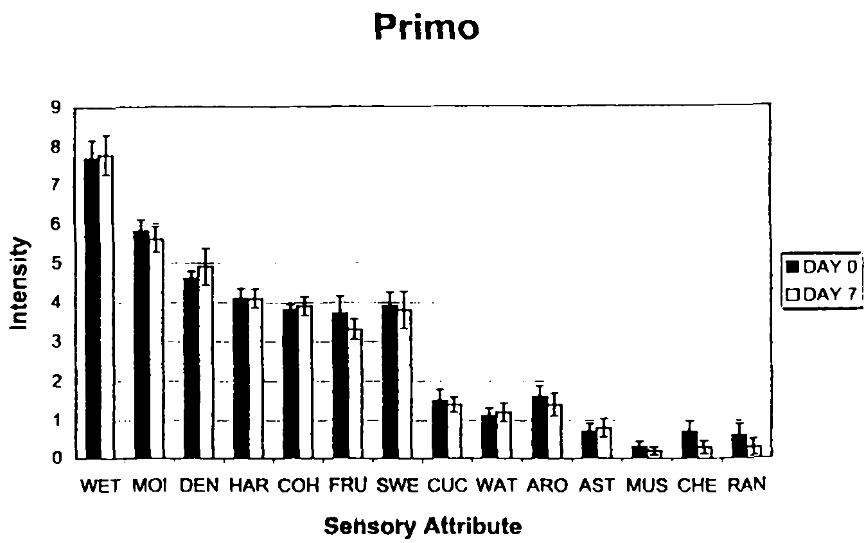

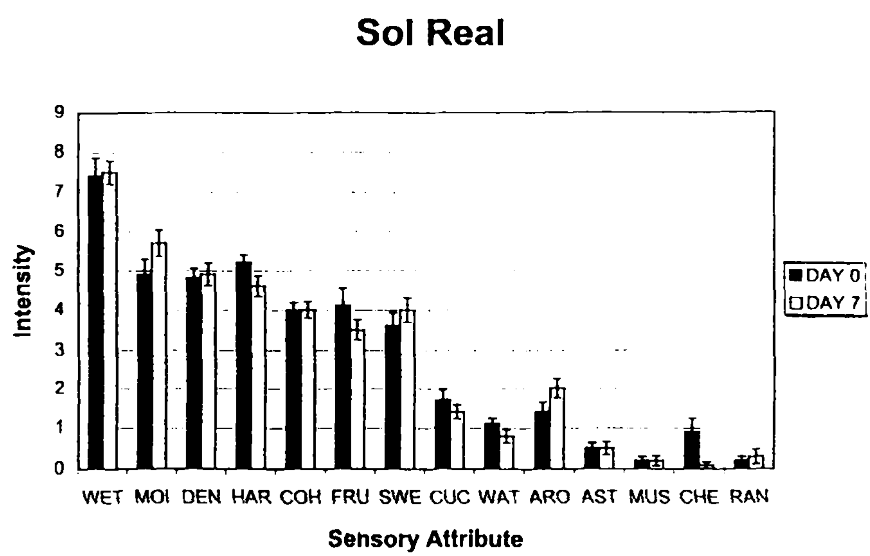

FIG. 1. MEAN INTENSITIES OF SENSORY ATTRIBUTES AT DAY 0 AND DAY 7 FOR (a) ATHENA, (b) PACSTART, (c) PRIMO AND (d) SOL REAL VARIETIES FOR 1999 AND 2000 CROPS, COMBINED
ARO = SweetAromatic, AST = Astringent, CHE = Chemical, COH = Cohesiveness, CUC = Cucurbits, DEN = Density, FRU = Fruity/Melon, HAR = Hardness, MOI = Moisture Release, MUS = Musty, RAN = Rancid/Painty, SWE = Sweet, WAT = Waterlike, and WET = Wetness.

after 10 DPP along with sweet taste. Since melons have no starch reserves, additional sugars cannot be synthesized in abscised fruit (Bianco and Pratt 1977; Lester and Dunlap 1985). However, substantial increases in sucrose concentration were found in abscised, fully mature 'Perlita' cantaloupe fruit; presumably at the expense of existing glucose and fructose pools (Lester and Dunlap 1985). Since SS remained constant when sweetness increased, it looks as though some conversion has taken place in these fruit. In the Primo variety sweet taste, sweet aromatic and fruit flavor had similar 0 and 7-day patterns (Fig. 1c). In Pacstart, sweet taste and fruity flavor had similar patterns and sweet aromatic decreased from 0 to 7 days (Fig. 1b). Athena had similar patterns between sweet taste and sweet aromatic (an increase) while fruity decreased (Fig. 1a). All of these flavors decreased in all the varieties at sometime between day-7 and day-14.

Sol Real (4.9) and Pacstart (5.0) were significantly harder than Primo (4.1) and Athena (4.4). Hardness didn't change much between 0 and 7 DPP for Primo and Pacstart. From the data in Fig. 1a-1d, it appeared that Sol Real and Athena softened during storage, but it was not consistent across both years. There were no definite trends during storage for any varieties except Sol Real decreased in hardness during storage for both years (data not shown). There was a significant storage day by crop year interaction. In 1999 all fruit softened between 0 (4.8) and 7 DPP (4.4) while in 2000 hardness was constant at 4.6.

Moisture release decreased during storage in Primo and Pacstart, and increased in Sol Real and Athena (Fig. 1a-1d). This trend was consistent for both crop years (data not shown). Although, when multiple days of storage were observed, moisture release in most cases tended to peak at 3 to 7 DPP, then decrease. This was unobservable in the statistical analysis on 0 and 7 DPP of storage. Athena (5.9) and Primo (5.7) had consistently more moisture release over both years than Pacstart (5.1) and Sol Real (5.2) (Fig. 1a-1d). Although, only Pacstart was statistically significantly less than Athena and Primo.

Athena (8.2) had significantly more surface wetness than the other varieties (Pacstart = 6.3, Primo = 7.8 and Sol Real = 7.4). Primo did not change during storage. Pacstart decreased, while Sol Real and Athena exhibited a slight increase during storage from 0 to 7 DPP, but not significant (Fig. 1a-1d). There was a significant interaction effect between crop year and storage day. In 1999, 0 DPP = 8.5, and 7 DPP = 8.1, while in 2000 0 DPP = 6.9 and 7 DPP = 7.3. Storage time had no consistent effect on perception of surface wetness.

Cohesiveness had a significant storage effect. Overall it increased between 0 and 7 DPP, but the 1999 crop did not change much (0 = 4.0 and 7 = 3.8), while the 2000 crop (0 = 3.9 and 7 = 4.3) increased. There is the possibility that this trend is real and that the additional experience of the panel members by 2000 helped them discern it better than in 1999.

TABLE 4.
MEAN SOLUBLE SOLIDS (BRIX°) OF FRESH-CUT CANTALOUPE CUBES (n=15) STORED AT 4C IN JUICE CATCHER CONTAINERS

Variety	0	5	7	10	14
1999					
Athena	9.8 bc	10.9 ab	9.3 c	11.0 a	n.d.
Pacstart	8.4 a	8.1 a	8.6 a	8.0 a	n.d.
Primo	11.8 a	12.1 a	11.1 a	11.3 a	n.d.
Sol Real	11.9 a	12.2 a	12.4 a	11.7 a	n.d.
2000					
Athena	12.2 a	12.0 a	n.d.	11.9 a	11.2 a
Pacstart	10.4 a	n.d.	10.0 a	n.d.	8.5 b
Primo	11.0 a	n.d.	12.0 a	n.d.	9.9 b
Sol Real	11.4 a	10.8 a	n.d.	11.6 a	11.0 a

n.d. = not determined.
a,b,c,d = means with different letter notations are significantly different between storage days based on Tukey's HSD test.

Year had a significant effect on astringent mouthfeel (1999 = 1.0 and 2000 = 0.5). Although not significant, Pacstart (0.9) was the most intense and Sol Real (0.5) was the least intense. Although not significantly different astringency increased during storage in 1999 in all varieties, but in 2000 it decreased or remained the same over time (data not shown). This indicates that fresh-cut storage does not affect astringent mouthfeel in a consistent manner.

There was a significant year effect on several of the sensory attributes, such as fruity. For every variety, the 2000 crop year had more intense fruity flavor than the 1999 crop year. Since year is confounded with the calibration of the panel it is difficult to determine what changes were caused by weather conditions and what is due to panel drift (changes in panelists' perception) from year to year. Panel drift is minimized by using references for intensity, but with fresh fruit there is no available internal standard to make comparisons which determine the extent of year-to-year panel drift.

Through work with fresh-cut melons at SRRC, it has been observed that at 4C very little off-flavor development has occurred. Some of the attributes we would expect to see increase as the fruit deteriorates are musty, chemical or fermented. These only increased between 0 and 7 DPP for Athena and it was not statistically significant. In some unpublished observations where melons were stored at 10C instead of 4C, the chemical and fermented flavor showed signs of increasing. The only problems we see when fruit is stored at a consistent 4C is the decrease in fruity flavor and some decrease in hardness. Sweet intensity tends to peak at around 7 $\pm$ 2 DPP and then it decreases. Cohesiveness increased with storage, which might indicate a toughening of the cell walls or a decrease in turgor pressure.

SUMMARY

Fresh-cut cantaloupe stored at 4C for 7 to 14 DPP did not develop off-flavors. It would take more abusive temperatures to increase off-flavors. The desirable flavors (fruity, sweet aromatic and sweet taste) decreased in intensity after the first seven days following processing. The time lapse between processing and consumption needs to be minimal. Temperature of storage needs to be as close to 4C as possible to prevent off-flavors. Distribution needs to occur the same day as processing. Independent of variety, sweet taste and fruity decreased in intensity at the end of the storage time (10-14 DPP). More work is needed to determine the effect of increased storage temperatures on the loss of desirable flavors and development of off-flavors.

ACKNOWLEDGMENTS

We express thanks to Dean Liere and Alex May (Syngenta Inc., Rogers Seeds) for supplying melons. We also thank Amber D. Harts, Myrna Franklin and James A. Miller for laboratory assistance. The mention of firm names or trade products does not imply that they are endorsed or recommended by the United States Department of Agriculture over other firms or similar products not mentioned.

REFERENCES

AULENBACH, B.B. and WORTHINGTON, J.T. 1974. Sensory evaluation of muskmelon: is soluble solids content a good quality index? HortScience *9*(2), 136–137.

AYHAN, Z., CHISM, G.W. and RICHTER, E.R. 1998. The shelf-life of minimally processed fresh-cut melons. J. Food Quality *21*, 29–40.

BEAULIEU, J.C. 2001. In search of a better tasting fresh-cut fruit. Fresh Cut *April*, 14–16.

BEAULIEU, J.C. and BALDWIN, E.A. 2002. Flavor and aroma of fresh-cut fruits and vegetables. In *Fresh-cut Fruits and Vegetables: Science, Technology and Market*, Chapt. 12, (O. Lamikanra, ed.) pp. 391–425, CRC Press, Boca Raton, FL.

BEAULIEU, J.C. and GRIMM, C.C. 2001. Identification of volatile compounds in cantaloupe at various developmental states using solid phase microextraction. J. Agric. Food Chem. *49*(3), 1345–1352.

BERRY, D.A. 1987. Logarithmic Transformations in ANOVA. Biometrics *43*, 439–456.

BETT, K.L. 2002. Evaluating sensory quality of fresh-cut fruits and vegetables. In *Fresh-cut Fruits and Vegetables: Science, Technology and Market*, Chapt. 13, (O. Lamikanra, ed.) pp. 427–438, CRC Press, Boca Raton, FL.

BETT, K.L., SHAFFER, G.P., VERCELLOTTI, J.R., SANDERS, T.H. and BLANKENSHIP, P.D. 1993. Reducing the noise contained in descriptive sensory data. J. Sensory Studies *8*, 13–29.

BIANCO, V.V. and PRATT, H.K. 1977. Compositional changes in muskmelon during development and in response to ethylene treatment. J. Amer. Soc. Hort. Sci. *102*, 127–133.

CURRENCE, T.M. and LARSON, R. 1941. Refractive index as an estimate of quality between and within muskmelon fruits. Plant Physiol. *16*, 611–620.

LESTER, G.E. and DUNLAP, J.R. 1985. Physiological changes during development and ripening of 'Perlita' muskmelon fruits. Sci. Hortic. *26*(4), 323–331.

MEILGAARD, M., CIVILLE, G.V. and CARR, B.T. 1999. *Sensory Evaluation Techniques*, 3rd Ed., pp. 387, CRC Press, Boca Raton, FL.

MUTTON, L.L., CULLIS, B.R. and BLAKENEY, A.B. 1981. The objective definition of eating quality in Rock Melons (*Cucumis Melo*). J. Sci. Agric. *32*, 385–391.

O'CONNOR-SHAW, R.E., ROBERTS, R., FORD, A.L. and NOTTINGHAM, S.M. 1994. Shelf-life of minimally processed honeydew, kiwifruit, papaya, pineapple and cantaloupe. J. Food Sci. *59*, 1202–1206, 1215.

O'CONNOR-SHAW, R.E., ROBERTS, R., FORD, A.L. and NOTTINGHAM, S.M. 1996. Changes in sensory quality of sterile cantaloupe dice stored in controlled atmosphere. J. Food Sci. *61*, 847–850.

PORTELA, S.I. and CANTWELL, M.I. 1998. Quality changes of minimally processed honeydew melons stored in air or controlled atmosphere. Post Harvest Biol. Technol. *14*, 351–357.

PRATT, H.K. 1971. Melons. In *The Biochemistry of Fruits and Their Products*, (A.C. Hulme, ed.) pp. 207–232, Academic Press, New York.

SHALITIN, D. and WOLF, S. 2000. Cucumber mosaic virus infection affects sugar transport in melon plants. Plant Physiol. *123*(2), 597–604.

WYLLIE, S.G., LEACH, D.N., WONG, Y. and SHEWFELT, R.L. 1995. Key aroma compounds in melons: Their development and cultivar dependence. In *Fruit Flavors: Biogenesis, Characterization, and Authentication. ACS Symposium Series 596*, pp. 249–257, American Chemical Society, Washington, DC.

YAMAGUCHI, M., HUGHES, D.L., YABUMOTO, K. and JENNINGS, W.G. 1977. Quality of cantaloupe muskmelons: Variability and attributes. Sci. Hortic. *6*(1), 59–70.